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**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554**

In the Matter of:

)MM Docket No. 99-325

***Digital Audio Broadcasting Systems
And Their Impact on the Terrestrial
Radio Broadcast Service***

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To: The Commission,

On December 3rd, 2001, the National Radio Systems Committee (NRSC), sponsored by the National Association of Broadcasters and the Consumer Electronics Association, submitted a report from the Evaluation Working Group of the DAB Subcommittee of the NRSC entitled *Evaluation of the iBiquity Digital Corporation IBOC System , Part I – FM IBOC*.

By the public notice , issued on 12/3/2001 the Commissioners sought public comment on the NRSC report, conclusions, and recommendations concerning the iBiquity hybrid mode FM IBOC DAB system, as well as on the iBiquity FM IBOC test results, with respect to the Commission's stated DAB policy goals and selection criteria.

In the NPRM dated November 1st, 1999, the Commission defined and stated as its policy goals for a new terrestrial Digital Audio Broadcast (DAB) service and sought comment on terrestrial in-band, on-channel (IBOC) AM and FM DAB systems and AM and FM DAB systems based on allocation of new radio spectrum in different frequency bands.

The Commission also stated in the NPRM its belief that it is necessary and appropriate to rely on some degree on the expertise of the private sector for DAB system evaluations, and listed the following 10 tentative selection criteria for DAB systems:

1,2) Enhanced Audio Fidelity/Robustness to interference, criteria are referred to and defined in paragraph 21 of the NPRM dated November 1st, 1999 as follows:

21. (1), (2) *Enhanced audio fidelity/robustness.* Consumer demand for improved audio fidelity is undeniable.⁶³ Access to superior digital audio technologies, such as compact discs and – in the near future – satellite DARS, and the perceived benefits of digitalization generally, fuel such demand. We believe that an important benefit of DAB will be enhanced sound quality. DAB technology should permit significant improvements in audio fidelity and robustness over our current analog service. For example, USADR and Lucent anticipate that AM hybrid IBOC DAB systems will offer sound quality comparable to today's stereo FM systems, and that FM

⁵⁹ See *Petition* at 3-4 ("It is estimated that there are over 550 million radio receivers in use today in the United States. Over 70 million new receivers are sold each year.") (citations omitted).

⁶⁰ See *Docket No. 90-357 R&O*, 10 FCC Rcd at 2315 (expressing support for the development of IBOC AM and FM systems); *Docket No. 90-357 NPRM*, 7 FCC Rcd at 7780-81 (Commission "continue(s) to support efforts to implement terrestrial in-band DARS technology").

⁶¹ Comments of CEMA at 10.

⁶² Comments of NPR at 3.

⁶³ See *Docket No. 90-357 NPRM*, 7 FCC Rcd at 7778 (discussing rapid consumer acceptance of new digital audio technologies). Lucent cites a consumer study it commissioned which "shows that over two-thirds of the radio buying population between the ages of 16-52 is interested in digital radios for the audio content-related innovations offered by enhanced AM and FM systems." Comments of Lucent at 5; see also Comments of CEMA at 4 ("Although radio continues to be a strong medium, it is clear that there is consumer demand for improved service and enhanced audio quality."); cf. *Inquiry Pursuant to Section 706 of the Telecommunications Act of 1996*, Report in CC Docket No. 98-146, 14 FCC Rcd 2398, 2400 (1999) ("Increasingly, all electronic communications are becoming digital.").

hybrid IBOC DAB systems will deliver near-CD quality sound.⁶⁴ As to robustness, DAB systems may improve reception by using techniques that protect digital signals from many forms of impairment that affect analog signals. We seek comment on these selection criteria, including the specific standards that should be used to compare competing systems.

We comment that the test results of the iBiuity system reveal that the "near CD sound quality will not be achieved even under the most optimistic test conditions because the 96K bandwidth is insufficient to produce "near CD quality except by relying on "psychoacoustic test" results that are subjective, and very suspect. They are prone to extreme measurement error.

We note the advanced age of the fifty-five subjects, attending an NAB convention (an inappropriately composed test group probably more likely to represent the broadcast interest advocacy position, than a neutral or skeptical position).

The poor selection of neutral test subjects and failure to include females and younger people with unimpaired high frequency hearing is testament to the very low quality of this testing work!

The FCC should insist on much more stringent selection criteria, and include far larger equal numbers of men and women of all ages and viewpoints, since this is subjective testing, and easily skewed by small, pre-selected by occupation, and non double-blind study methodology.

Given this transparent attempt to skew the results in favor of iBiquity IBOC, subjective test methodology should be dispensed with, as a valid test criteria for proof or assurance that the audio quality meets the "Near CD Quality" standard suggested by USADR and Lucent.

Only actual OBJECTIVE testing can prove or assure that the criteria for enhanced audio quality, using conventional audio distortion, signal to noise ratio and spectral power density distribution will protect the public's right to preserve the audio quality, and continued use of the FM broadcast band, at all rf signal levels, (no just those in the so called "protected contour")

Any additional improvement in audio signal quality or immunity from interference attributable to so called "Psychoacoustic (noise masking) Testing" should be welcomed as an unmeasurable bonus

Al, but as yet unmeasurable bonus, but should not be considered by the Commission as OBJECTIVE PROOF of superior audio signal quality or interference reduction

While OBOC technology has been tested, better analog receivers have allowed greater sensitivity and enhanced reception range with good SNR than the older models permitted. These newer receivers perform well far beyond the so-called "protected contour. Since iBiquity proposes to INTENTIONALLY introduce interference into the FM broadcast band, existing listeners, either within or outside the analog protected contours deserve protection from IBOC interference

3) Compatibility with existing analog service, criteria are referred to and defined in paragraph 22, 23, 24 and 25 of the NPRM dated November 1st, 1999 as follows:

22. IBOC systems are designed to operate in two fundamentally different RF environments. In the hybrid mode, an IBOC system must make certain trade-offs to avoid interference to in-band analog transmissions. Although the sharing of spectrum may facilitate a transition to DAB, it may also result in lesser digital performance during the transition period. Accordingly, a comparison of IBOC and new-spectrum alternatives must consider the time frame within which either system could achieve all-digital operations and the short-term performance advantages, if any, of hybrid IBOC digital systems over the current analog service. We seek comment on this issue. A related question is whether the trade-offs necessary to permit IBOC digital transmissions in the hybrid mode would extend into the all-digital world, i.e., limit the potential for enhanced audio fidelity and robustness in comparison to non-IBOC alternatives. We seek comment on the appropriate ways of comparing IBOC and new-spectrum DAB alternatives under these selection criteria.

23. (3) Compatibility. A DAB system must be compatible with the continued operation of existing radio broadcast stations. This appears to be a criterion of relevance primarily to in-band systems.⁶⁵ Most commenters agree with NAB's position that "the implementation of an IBOC DAB service that causes significant impairment to existing analog service would raise serious questions as to the suitability of the system."⁶⁶ We tentatively conclude that IBOC systems should minimize interference to reception of host and adjacent-channel analog signals during hybrid mode operations including, for FM stations, interference to subcarriers.

24. To a significant extent, the opportunity to introduce new ancillary services in both the USADR and Lucent systems is tied to the initiation of all-digital operations. In this regard, however, it appears that the Lucent and USADR systems differ in one important respect. Unlike Lucent's, USADR's all-digital mode transmissions could interfere with an adjacent channel station transmitting an analog signal. As a result, initiation of all-digital operations under USADR's system would not be possible until a fixed analog "sunset" date, *i.e.*, a date when stations transmitting analog signals would lose their current interference protection. A system that permits stations to implement rapidly an all-digital radio service may serve the public interest better than one that delays the opportunity to fully realize the benefits of DAB until the end of what is likely to be an extended transition period. On the other hand, we recognize the potential benefit of a fixed analog "sunset" date in fostering a transition to an all-digital service.⁶⁷ We seek comment on whether, with regard to an IBOC system, all-digital compatibility with analog signals should be an evaluative criterion.

25. We also seek comment on the compatibility of IBOC systems and the proposed low power FM ("LPFM") service. In our *LPFM Notice*, we recognized the importance of taking into consideration "the implications of 2nd-adjacent channel protection for the possible conversion" to a DAB system.⁶⁸ We asked whether we should impose a 2nd adjacent channel protection requirement on LPFM stations "for the purpose of protecting a possible future digital radio technology, considering that creating opportunities for new radio service is also an important Commission goal."⁶⁹ Similarly, we ask here how a DAB system could be designed to protect a possible future LPFM service. Both Lucent and USADR expressed concern about the impact of LPFM on DAB but it appears that the possible relaxation of 3rd adjacent channel protection standards for LPFM would have no material impact on digital signal reception. "Because of the design of the USADR IBOC system, digital reception is essentially not susceptible to third adjacent channel interference; nor is IBOC likely to increase the potential for causing such interference to analog stations."⁷⁰ Specifically, we seek comment on the potential for enhancing the robustness of IBOC systems to reject undesired 2nd and 3rd adjacent channel signals, and the likely impact of such modifications.

We comment that Fig 10 below (From the NRSC report, dated 3 Dec. fails to support the NRSC's own conclusion that "With respect to carriers that are located 1st adjacent to an IBOC signal, listeners within the protected contour SHOULD NOT PERCEIVE an impact on the analog host signal..." and that "(only) "A limited number of listeners MAY PERCEIVE an impact outside the protected contour" are not proven by any OBJECTIVE test, but rather improperly rely on SUBJECTIVE psychoacoustic (Noise Masking) test criteria. We comment that the public's right to continued use of the FM broadcast band will be severely impaired. We offer further comments below on the improper testing, delineated by our use of asterisks(**)

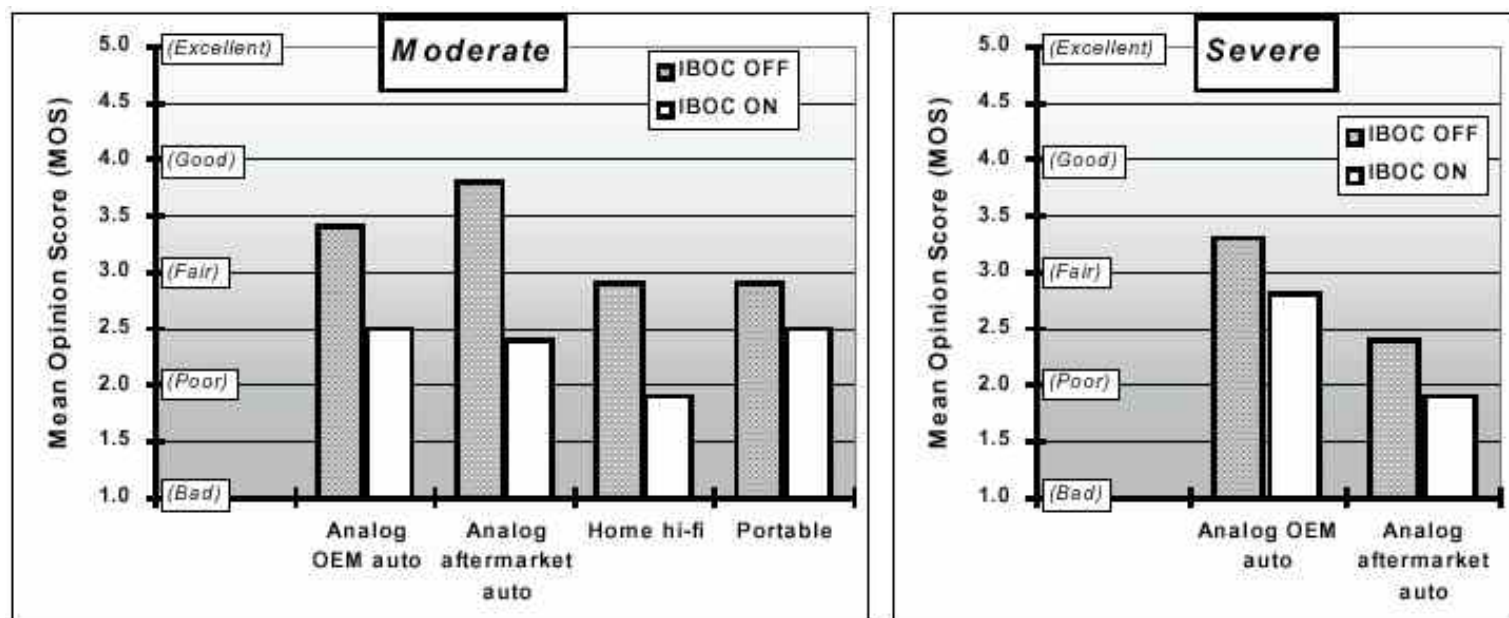


Figure 10. 1st-adjacent compatibility - subjective evaluation results of audio recordings obtained in the field (speech programming)

Moderate: +16 to +6 dB D/U

Severe: +6 to -9 dB D/U

The results shown in Figure 10 serve to illustrate one of the greatest compatibility challenges facing FM IBOC, operation with 1st-adjacent channel interference (discussed in greater detail below in Section 4.12.2), and were obtained in the presence of moderate (between +16 and +6 dB D/U) and severe (between +6 and -9 dB D/U) 1st-adjacent channel interference. These results indicate that under certain circumstances, for certain radios, the presence of the IBOC digital sidebands will have a noticeable effect on analog receiver audio quality. For example, the audio quality of the analog aftermarket auto radio, under moderate interference conditions, is reduced from the “good” range (with no IBOC present) to the “poor” range (with the IBOC digital sidebands present on a 1st-adjacent channel interferer).

By comparing the difference between the “IBOC off” and “IBOC on” performance for the analog OEM auto radio and the analog aftermarket auto radio shown in Figure 10, for the moderate and severe cases, one of the performance behaviors of analog radios which affects compatibility is highlighted—as the interference level increases, the impact of the IBOC digital sidebands on analog receiver performance becomes less noticeable. Specifically, notice how the difference between IBOC on and IBOC off for the analog aftermarket auto radio (in terms of MOS) is about 1.5 in the moderate case, but only about 0.5 for the severe case, a significant reduction.

This last point, that the amount of interference has a bearing on compatibility, has important ramifications for laboratory testing, since one important interference signal which exists in all radio reception environments, that of RF “background noise,” is not normally present when co- and adjacent-channel laboratory tests are performed. Because of this, the NRSC decided to add a background noise component to the RF signals under test during compatibility testing, so that the results of subsequent subjective evaluation would be more realistic. The actual amount of RF white noise added, corresponding to 30,000K, was based on studies done by iBiquity.¹⁸ Lab measurements were also made with no added noise as a “sanity check,” providing a baseline for comparison in case the results with the artificial noise added turned out to be very different than the real world results obtained in the field. As was expected, the 30,000K results did not turn out to be very different from the field results.

2.1.4 Additive White Gaussian Noise

For *all* analog compatibility tests, the channels of interest are subjected to additive noise at a level of 100,000° Kelvin. This noise shall have flat spectral characteristics across the channels of interest ('white' spectrum) and its peak amplitude excursions shall have a Gaussian probability distribution. An FM bandpass filter will be used on the output of the noise generator in order to prevent the naturally wideband noise from overloading the 'front end' of instrumentation in the test bed.

Section 3.1.5 describes the procedure used to determine and set the power level of this additive white gaussian noise.

⁴ USA Digital Radio (USADR), "Petition for Rulemaking to the United States Federal Communications Commission for In-Band On-Channel Digital Audio Broadcasting", 10/07/98

We comment that hybrid FM is incompatible with analog FM.

4) The Spectrum Efficiency criteria are referred to and defined in paragraph 26, 27 and 28 of the NPRM dated November 1st, 1999 as follows:

26. (4) *Spectrum efficiency*. The Commission is committed to establishing a spectrally-efficient terrestrial DAB service. We recognize that certain basic design and regulatory trade-offs are inherent in all analog and digital systems. As Lucent observes, "there are multiple different pairings of attributes possible that would be capable of delivering digital audio in an IBOC configuration."⁷¹ Lucent and USADR assert that IBOC is spectrum efficient in the sense of not requiring additional spectrum to implement digital transmissions. They also contend that IBOC would not encumber additional spectrum because the IBOC signal would be contained by the emission masks for the analog channels and has been developed around the existing analog interference protection criteria. However, spectrum efficiency as a selective criterion also concerns the additional value that results from the transition from an analog to a digital transmission service. In the instant context, the added value of spectrum is the product of several factors. These include the capacity of digital technologies to transmit greater amounts of data per hertz, enhanced flexibility, the ability to design digital systems that are less likely to cause interference, less susceptible to interference, and more robust with respect to multipath fading and non-radio noise sources, and the capacity to provide a listenable service at relatively low signal strength levels.

27. This proceeding also presents an opportunity to consider the spectral efficiencies that could be realized by advances in receiver technology over the decades since the analog interference standards were established. We note that analog receivers can now be designed with improved frequency selectivity to better reject potentially interfering signals on adjacent channels.⁷² Although IBOC systems are based on existing analog protection criteria,⁷³ we wish to examine the extent to which state-of-the-art receiver technology may provide additional protection against interference, and thereby facilitate more intensive spectrum utilization. What

⁶⁸ *LPFM Notice*, 14 FCC Rcd at 2490.

⁶⁹ *Id.* at 2492.

⁷⁰ *Petition*, Appendix D at 3.

⁷¹ Comments of Lucent at 8.

⁷² See Comments of Ford at 8.

would be the additional cost to consumers of receivers with state-of-the-art immunity? Are there design considerations other than cost that would practically limit interference immunity?

28. At this preliminary stage, it is clear that the Commission needs additional information about the specific mix of DAB design attributes that could best meet the current and future needs of *all* stakeholders in our free, over-the-air broadcasting system. Therefore, we seek comment on possible DAB spectrum efficiency standards. Are any of the Eureka-147 DAB and/or satellite DARS signal bandwidth and interference protection standards relevant in establishing DAB spectrum efficiency standards for IBOC and/or non-IBOC DAB systems? What bandwidth is necessary for DAB systems to achieve CD-quality audio signals? What are the spectrum implications of recent advances in coding and multistreaming technologies on the ability to deliver CD-like audio quality? With regard to each proponent's DAB system, what are the quantifiable trade-offs between bandwidth and signal robustness? What power, interference, and bandwidth trade-offs should the Commission consider in balancing the needs of incumbents and potential new entrants? Should there be different data capacity criteria during and after the transition to all-digital operations? Would the transition to all-digital service be slowed if incumbents were assigned less bandwidth for all-digital operations than their current channel assignments? Is preserving (or expanding) current AM and FM bandwidth assignments necessary for consumers to receive the full benefits of DAB, including a rapid implementation of an all-digital DAB system?

5,6) The Flexibility/auxiliary criteria are referred to and defined in paragraph 29 and 30 of the NPRM dated November 1st, 1999 as follows:

29. (5), (6) *Flexibility/auxiliary capacity*. Flexibility is one of the principal benefits of digital technology. Many commenters believe that increasing radio broadcasters' capacity to provide auxiliary services will be an important benefit of DAB technology. The Commission is committed to encouraging a DAB system design that would permit the flexible and dynamic development of new broadcast and non-broadcast services and features and allow broadcasters to realize specific service opportunities. We currently provide broadcasters with a great deal of freedom with regard to subcarrier usage and believe that a similar approach to regulating augmented auxiliary capacity would likewise be in the public interest.⁷⁴

We comment that the flexibility criteria benefit the broadcast interest far more than any public interest, and should be given a very low priority.

30. In this regard, the Telecommunications Act of 1996 requires the Commission to permit DTV licensees to provide ancillary or supplemental services, so long as such services do not derogate the free television broadcast service, and to assess and collect a fee for such use when the licensee receives fees or other compensation from third parties.⁷⁵ We tentatively conclude that the provision of new and innovative ancillary services must not technically impair the reception of DAB programming. We seek comment on whether an analogous regulatory framework would be appropriate for the radio broadcast service and the limits, if any, we should establish for ancillary services.

The auxillary criteria benefit the broadcast interest far more than any public interest, and should be given a very low priority.

7) The Extensibility criteria are referred to and defined in paragraph 31 of the NPRM dated November 1st, 1999 as follows:

31. (7) *Extensibility*. We believe that a DAB system design also must be adaptable to future technological advances. As Lucent puts it, a DAB system should be structured "with 'headroom' to allow incorporation of future technological advances."⁷⁶ We tentatively conclude that extensibility is crucial to preserving a strong and competitive free, over-the-air broadcast system

⁷⁴ See *Notice of Inquiry* in MM Docket No. 87-268, 2 FCC Rcd 5125, 5137 (1987).

⁷⁵ See *Fees for Ancillary or Supplementary Use of Digital Television Spectrum, Notice of Proposed Rule Making* in MM Docket No. 97-247, 12 FCC Rcd 22821 (1997). We note that Eureka-147 systems evidently allow broadcasters to offer subscription services such as concerts.

⁷⁶ Comments of Lucent at 15.

in a digital communications environment, and to ensuring that listeners receive the full benefits of DAB. We seek comment on this view.

8) The Accommodation for Existing Broadcasters criteria are referred to and defined in paragraph 32 of the NPRM dated November 1st, 1999 as follows:

32. *(8) Accommodation for existing broadcasters.* We tentatively conclude that any DAB system should, to the maximum extent possible, accommodate all existing broadcasters that desire to initiate DAB system transmissions. A digital service that permits both AM and FM stations to provide the same level of enhanced audio quality also would be of significant benefit to broadcasters and listeners. We tentatively conclude, however, that placing AM and FM broadcasters on equal footing in terms of signal quality is not an essential DAB technical requirement. A digital AM service that would provide “FM-like” audio quality would create important new format choices for AM stations and could help revitalize this service. We seek comment on these views.

The iBiquity system jams rather than accomodates existing services , including LPFM.

9) The Coverage criteria are referred to and defined in paragraph 33 of the NPRM dated November 1st, 1999 as follows:

33. *(9) Coverage.* Broadcasters argue that any DAB system should be capable of replicating existing coverage areas. Such coverage areas tend to be greater than the “interference-free” areas protected under the Commission’s rules.⁷⁷ We recognize that preserving existing coverage areas may be an important aspect of ensuring a non-disruptive transition to DAB.⁷⁸ Nevertheless, we tentatively conclude that the public interest is best served through the development of a digital radio assignment policy that adopts current analog protected service contours for DAB. The Commission has recognized in several different contexts that stations generally provide useful service beyond their service contours in the absence of interference. However, service contours are not merely a function of the distance at which adequate reception is possible. Rather, these contours reflect a balance between providing adequate service areas and expanding the potential number of station assignments.⁷⁹ We believe that this longstanding policy is applicable here. We request comments on these views.

Coverage would be poorer especially for the multitudes of audiophiles with large investments in superb analog receivers.

10) The Implementation Costs/affordability of equipment criteria are referred to and defined in paragraph 34 of the NPRM dated November 1st, 1999 as follows:

34. (10) *Implementation costs/affordability of transmission and receiver equipment.* Minimizing implementation costs of any DAB model and/or system is a fundamental means of ensuring a rapid and non-disruptive transition to DAB. One important benefit of an IBOC model appears to be its ability to allow broadcasters to build on the existing broadcast infrastructure in transitioning to a DAB system. With regard to affordability, the *Petition* points out that the relatively low cost of receivers contributes to the radio broadcast service's unmatched penetration.⁸⁰ We wish to consider the costs to consumers of digital receivers as well, including the trade-offs between receiver performance and cost.

⁷⁷ The Commission's rules protect commercial FM stations from interference within specified service contours based on class maximum facilities. See 47 C.F.R. § 73.207. A USADR-commissioned study of the FM interference environment found that "within the protected contour the majority of stations—approximately 90 percent—lose less than 10 percent of their predicted coverage to interference . . . The median station serves approximately 60 percent of its potential noise limited coverage area [defined in the study as the predicted 44 dBu service area]." *Petition*, Appendix D at 28. Ford states that service also has been extended during the past 30 years by improvements in the sensitivity and selectivity of receivers. See Comments of Ford at 8.

⁷⁸ Ford and other commenters urge the Commission to take steps to protect the current radio service performance "geography" following the introduction of any new IBOC system. See *id.* at 10.

⁷⁹ See *Report and Order* in BC Docket 80-90, 94 FCC 2d at 161-163.

⁸⁰ *Petition* at 4 ("Although audiophiles can spend considerable sums on a high-end receiver, radio can also serve the listener who can only afford a basic portable or clock radio.").

We comment that the huge existing base of AM and FM Broadcast receivers would be rendered AM only for many users if the iBiquity system were permitted to co-exist on the current FM Band and the Commission should embrace the Eureka 147 band III system and make an additional band, potentially the L-Band at 1400MHz for a wide-band terrestrial system and place any system such as iBiquity on that band in lieu of ruining the investment in the low, medium and high quality receivers.